Amphibious vehicle steering

The present invention relates to amphibious vehicle steering.

Amphibious vehicles, hereafter "amphibians", are frequently steered in their land and marine modes by the same steering wheel. A simple form of amphibian steering is shown in US patent no. 5,727,494 (Caserta). In Caserta's proposal, a steering cable is arranged between a rear propulsion unit and the inner shaft of the steering column, which the cable is wound around, and thence back to the marine propulsion unit. Whilst this is a simple arrangement, it is unsuitable for high speed planing amphibians, where the force required to steer the propulsion unit is high. That is, the mechanical advantage of the Caserta arrangement is low. Where an automotive steering column is used, there is a high risk that the steering cable according to Caserta will conflict either with the mechanism designed to ensure crushability of the steering column in an accident; or alternatively, with any telescopic adjustment mechanism designed to ensure an ergonomic driving position.

In another proposal shown in US patent no. 5,590,617 (Gere), the linkages between the rear marine propulsion unit and the steering arrangement at the front of the vehicle are bulky and heavy, at a location at the front of the vehicle where weight has to be carefully controlled in a planing amphibian. Furthermore, the steering according to Gere is conformed so as to be operable in either a road mode or a marine mode. To allow this duality, the road steering system depends for operation on the steering rack being held in place by pressurized pneumatic rams. This is somewhat alarming from a safety viewpoint.

It is considered advantageous to have road and marine steering systems which can be operated simultaneously. This simplifies control systems, as there are less changes to be made in converting from road mode to marine mode or vice versa. Also, when manoeuvring at low speed in water, particularly to direct an amphibian to a slipway, the steering effect of dependent road wheels may be at least as great as that of, for example, a steering nozzle attached to a jet drive. Furthermore, if both systems can be operated together, there is no need for complex systems to ensure that when one or

the other system is switched in, it is always initially centred. Finally, there is a safety advantage, in that in the unlikely event of breakage or seizure of the steering cable, a second steering system is available. In this context, it should be noted that the marine steering is self-centring. In the absence of any control input or restraint of movement, passage of water through the jet steering nozzle will tend to centre the nozzle.

It is an object of the invention to provide a steering system for a planing amphibian in which the steering system is balanced, so that power assistance to the road steering matches the power assistance required to overcome the self centring tendency of the marine propulsion unit running at high speed. Another object is to reduce the bulk of parts of the steering assembly in the region between the front wheels, which have to retract to reduce water resistance in a planing amphibious vehicle.

According to the invention, there is provided an amphibious vehicle having retractable wheels and a planing hull, a marine propulsion unit, front wheels arranged to be steered by means of a power assisted transversely mounted element, an actuating rod mounted to said element, the rod arranged for transverse movement, and a flexible coupling means connecting said actuating rod to a steerable part of the marine propulsion unit, so that transverse movement of said element steers the part of the marine propulsion unit.

Preferably, the element is linked by means of a link to each wheel, the links being arranged to fold upwards on retracting the wheels. Both road and marine steering may be arranged to be operated simultaneously. The transversely mounted element may be a rack and pinion steering system. The flexible coupling means is preferably a push-pull cable and a bell-crank means attached to the actuating rod. The actuating rod may be mounted in front of a steering column. The push-pull cable arrangement, comprising a cable slidable in a sleeve, is readily arranged so as to fit between body members and the vehicle power train with a minimum bending radius of 150mm. In one embodiment, the cable is between 12 and 13mm in diameter, whilst the outer sleeve of the cable is between 15 and 17mm in diameter.

The steering system may be readily adapted to a steering system comprising more than one steered front axle. It could also be adapted to a marine propulsion system comprising more than one marine propulsion unit.

An embodiment of the invention will now be described by way of example with reference to the following drawings in which:

Figure 1 is a perspective view from above and behind, of the front wheel steering arrangement of an amphibian with retractable wheels according to the invention;

Figure 2 is a side view of one front wheel arrangement of the amphibian of Figure 1 in road mode, with the front wheel removed for clarity;

Figure 3 is a side view of the front wheel arrangement of Figure 2, in the wheel retracted position in marine mode; and

Figure 4 is a plan view of a marine propulsion unit of the amphibian of Figure 1, as steered by the steering arrangement of Figure 1.

In the drawings, Figure 1 shows on the left the front wheel hub assembly 2 with brake disc 4 and brake caliper 6. The hub assembly 2 is mounted to upper and lower wishbones 8 and 9, which enable piston and cylinder arrangement 12 to raise the front wheel from the position shown in Figure 2 to that shown in Figure 3. In doing so, link 14 (there is the same arrangement on the other side, shown at 14') folds upwards to the position 14'' shown in broken lines in Figure 1. (The folded position 14'' is shown for link 14', for clarity). Figure 3 also shows part of the hull 10 to which wishbones 8 and 9 are mounted via a mounting plate (omitted for clarity). The hull 10 has a planing bottom 11.

Coupled to links 14 and 14' is power assisted transversely mounted steering rack unit 16, actuated by a pinion in housing 18; which in turn is actuated by an inner steering column on axis 20, and finally by a steering wheel 22, shown diagrammatically at a severely reduced scale for clarity.

The rack movement is some 114mm lock to lock, whilst the steering wheel has 2,3 turns from lock to lock. Mounted to rack arm 24 is bracket 26, to which is in turn mounted link rod 28; to the other end of which is mounted bell crank 30. Crank 30 is pivoted about pivot 32, and coupled to push-pull cable 34; which is slidably mounted in flexible casing or sleeve 36. The coupling between rack arm 24 and bell crank 30 is such that rod 28 is in front of steering column 20. This ensures economy of space.

At the rear of the vehicle is marine propulsion unit 40, shown in Figure 4, which has a steering nozzle 42 pivotally mounted to propulsion conduit housing 44 at 46. Bolted to said nozzle is steering arm 48, to which the push-pull cable is coupled. Sleeve 36 is fixedly secured at 50 to flange 52 of housing 44. Sleeve 36 is 15 to 17mm in diameter, whilst cable 34 is 12 to 13mm in diameter. The cable and sleeve are arranged in the vehicle with a minimum bending radius of 150mm. A reversing bucket may be fitted to the steering nozzle, as is known in the marine engineering art.

It should be noted that further refinements may be made to the steering system described above without departing from the essential inventive concept. For example, the system is particularly suited to be adapted to a road steering system using "steer by wire"; that is, not having a mechanical linkage between the steering wheel and the transversely mounted steering element. Such a system would be particularly advantageous to an amphibian, in that the bulkhead ahead of the driver would be more easily sealed against passage of water without a conventional steering column passing therethrough. The power assisted steering system may be hydraulic, hybrid hydraulic/electric, electric, or magnetic. The input to the marine steering system could be taken from a steered rear axle. This would, however, require some means of control which accounted for the fact that most rear wheel steering systems sometimes steer the rear wheels out of phase with the front wheels; and sometimes in phase with them.

Where two or more marine propulsion units are used, their steering nozzles may be mechanically linked to ensure that they turn in phase with each other. Such a linkage may have some geometry comparable to Ackermann geometry for road steering. Where two or more front steered axles are used, they may both have hydraulic cylinders to

steer their respective wheels. With two steered front axles and two marine drives, a cable could be taken from each steered axle to a respective marine drive.

The fixing of the cable sleeve to the jet flange described above is a simple and cheap solution. It may be preferred to fix the cable sleeve to a jet flange by means of a bracket and locknuts, thereby allowing longitudinal adjustment of the cable sleeve; as is known in the marine engineering art.

The steering system described offers a fixed ratio between road and marine steering, which is fixed at the design stage by the lengths of the arms on the bell crank. The drawback of such a fixed ratio is considered to be outweighed by the system's compactness, simplicity, and light weight; each of which are particularly helpful where retractable wheels are fitted.